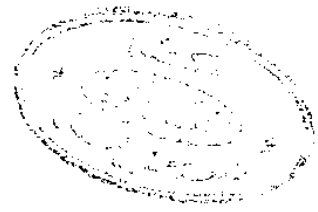
RESPONSE OF RICE PLANT TO MINERAL NITROGEN AND BIOFERTILIZATION

By

Adel Sayed Osman



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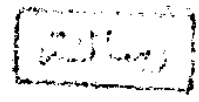

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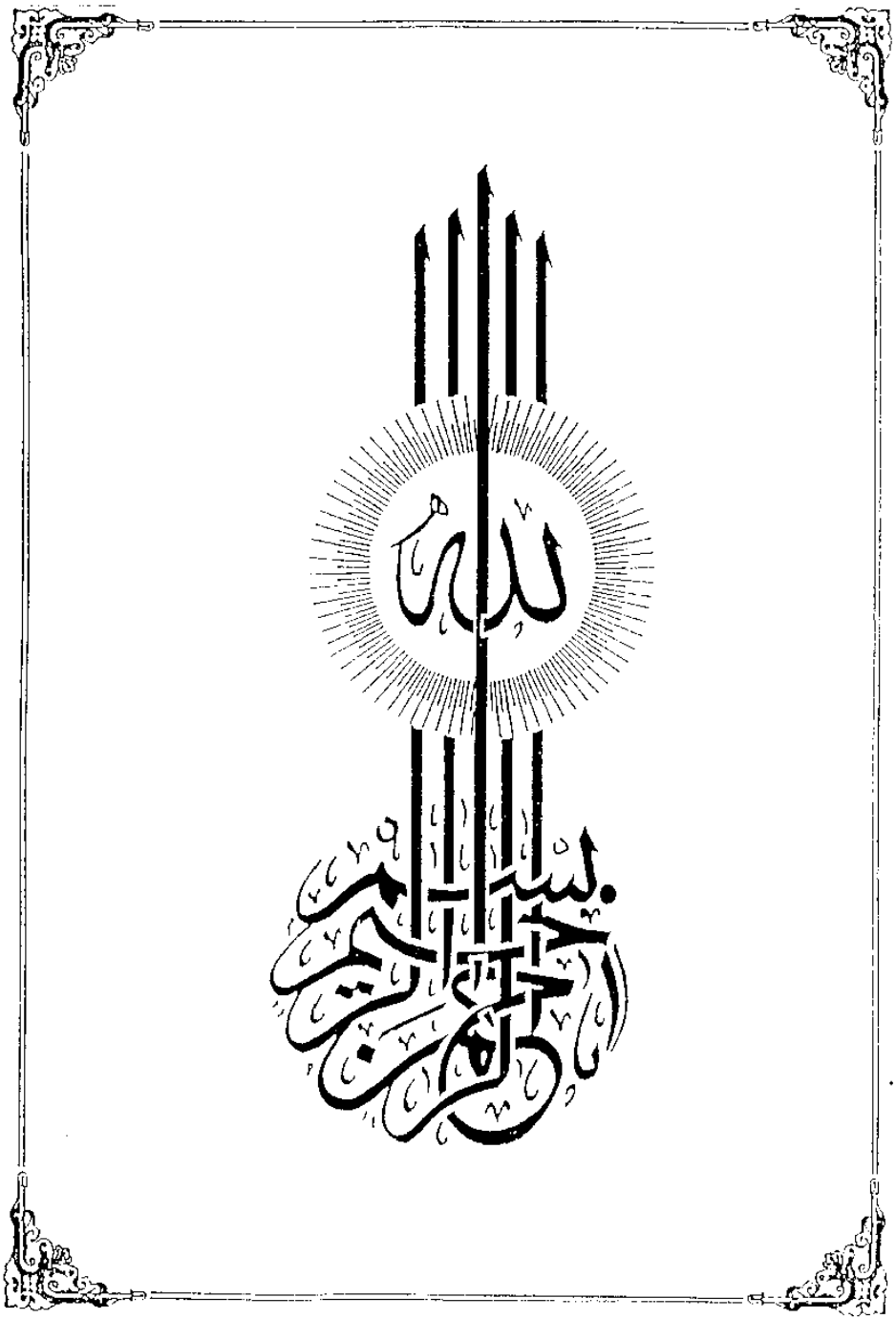

Egyptian crop rotation systems. Many efforts have been done to increase the grain yield of rice crop via mineral nitrogen fertilization or inoculation with free-living N_2-fixing organisms especially the blue-green algae.

The present work was designed to evaluate the algalization of rice fields in absence and in presence of chemical N-fertilizer and its effect on the growth and yield of rice.

REVIEW OF LITERATURE

The need of rice plants to nitrogen fertilizer is a well known fact allover the rice producing countries. However, the optimum amount and type of nitrogen fertilizer differ according to several factors, e.g. location, soil conditions, rice variety, rotation, preceeding crop, management practice .... etc.

The nitrogen can be supplied to rice plants either through chemical fertilizers and/or biofertilizer (nitrogen fixing cyanobacteria). The recent publications related to the effect of chemical nitrogen fertilizer as well as nitrogen fixing algae are being reviewed below.

Effect of nitrogen fertilizer:

Chemical nitrogen fertilizer proved to increase significantly the rice yield over the control having no chemical nitrogen fertilizer (Awan *et al.*, 1984; Buntan and Corpuz, 1989). Rice did significantly respond to nitrogen application as crop yield and total nitrogen uptake by plant as the rate of nitrogen increased up to 90 kg N/ha (Hamissa *et al.*, 1980), 67 kg N/ha (Gill, 1981), 60 kg N/ha (Patel *et al.*, 1983), 87 kg N/ha (Kumar and Singh, 1983), 80 kg N/ha (Rabindra *et al.*, 1983) and to 40 kg N/ha (Krisnarajan *et al.*, 1984). Some authors used much higher amounts of nitrogen fertilizer. Balasubramaniyan (1984) found that 120 kg N/ha gave higher rice yield. Gulati *et al.* (1987)

indicated that paddy (grain) and straw yield increased with increasing nitrogen level up to 150 kg N/ha, while Singh *et al.* (1989) found that applicaton of 180 kg N/ha gave significantly higher grain and straw yield as well as protein yield and nitrogen uptake.

The effect of chemical nitrogen fertilization on various rice plant characters (i.e. plant height, number of tillers, panicle weight, grain yield, straw yield .....etc.) were studied by many research workers. Number of tillers/plant, grain yield and all major yield components were significantly increased as nitrogen application rates increased (Ghobrial, 1983; Singh *et al.*, 1983; Jashim *et al.*, 1984; Ram *et al.*, 1984; Aly *et al.*, 1985; Gill, 1985; Grewal and Gill, 1985; Mahrous *et al.*, 1985; Ramasamy *et al.*, 1985; Singh *et al.*, 1985; Reddy *et al.*, 1986; Aly *et al.*, 1987; Prasad and Singh, 1987; Reddy *et al.*, 1987 and Singh and Sharma, 1987).

Patwary *et al.* (1988); Reddy *et al.* (1988) and Raffey *et al.* (1989) reported that mean and range value for grain yield, plant height and protein content generally increased with respect to nitrogen levels between 100-200 kg N/ha during two seasons. Similar trend was given by Shaalan *et al.* (1987) regarding to grain yield, number of ear-bearing tillers, panicle weight, plant height and protein content.

Increasing nitrogen rates from 0 to 100 kg N/ha (Biswas and Bhattacharya, 1987) increased the paddy yield from 3.5 to 5.0 t/ha in the wet season and from 2.7 to 3.7 t/ha in the dry season. Thorate and Patil (1987) stated that increasing nitrogen rate from 0, 60 and 120 kg N/ha increased the paddy yield from 1.9 to 2.9 and 3.7 t/ha and total nitrogen uptake from 20.4 to 47.1 and 69.5 kg N/ha, respectively. Tiller production, leaf-area index, root production and grain yield increased with urea application up to 90 kg N/ha (Salam and Kerala, 1989). Similar results on tillers per hill and straw yield was noticed by Hussain *et al.* (1989) and Patra and Padhi, (1989). However, in Egypt, rice plant are fertilized at present with either urea or ammonium sulphate. The recommended rate of application is 40 kg N/fed. or 100 kg N/ha (Hamissa *et al.*, 1980).

Algalization of rice fields:

Blue-green algae (BGA) were one of the first nitrogen fixing agents recognized to be active in flooded rice soils. Since De in 1939 attributed the natural fertility of the tropical paddy fields to these organisms. Several studies have been conducted to increase rice yield by algal inoculation of the soil. This practice, known now as algalization, according to Venkataraman (1981) who has been reported to have a beneficial effect on grain yield in different countries. However, there are still some more information needed to justify exact effect of algalization

on rice plants. Among the points which still need confirmation under field scale are, the variation of nitrogen fixing algal strains, amount of inoculum in relation with chemical fertilizer, relation with previous crops, time of application ... etc.

The published work since 1970 up to 1990 are summarized below;

As cultivation conditions of paddy differs from country to other with different management practices and environmental conditions, e.g. soil pH, temperature, rotation or succession cultivation, thus it may be more appropriate to reveiw results in each country separately.

In Egypt:

Abou-el-Fadl *et al.* (1970) indicated that when rice was cultivated after flax; it responded to algal application giving an increase in yield equal to 15.3%, while the response to 20 kg nitrogen was 13.5%. The use of 10 kg N alone gave an increase in yield of 10.2%. In open field trials, when ammonium sulphate and super phosphate were applied 4 weeks later than the alga, a significant increase of 22% in rice yield was observed. A conclusion was reached that the use of alga would substitute for 10 kg N fertilizer required for rice. Also, Ibrahim *et al.* (1971) found that inoculation with alga showed a definite beneficial effect on the yield of rice grain and straw and their N contents.

Algal inoculation without the application of any fertilizer, increased the yield of rice grain and straw by 4.2 and 19.3%. Nitrogen content of the soil was significantly increased by algal inoculation (Hamissa *et al.* (1979). The same trend was obtained with regard to the amounts of N uptake by the plants in the inoculated treatments compared with the control. Algalization in combination with N application produced higher yields of paddy and higher amounts of N taken by the plants than those obtained from either algae or N when added alone.

Alaa El-Din *et al.* (1982) indicated that the inoculation of rice plants with *Tolypothrix tenius* at the rate of 200 g/fed. with addition of 10 kg N/fed. and 100 g/fed. with addition of 20 kg N/fed. increased the rice yield up to 71.5% and 25.8% of the control for the rice cultivated after legume and non-legume, respectively. The increase of rice yield cultivated after legume or non-legume as a result of inoculation with mixed inoculation of *Tolypothrix tenuis and Anabaena oryzea* at the rate of 100 g/fed. in the presence of 10 kg N/fed. and 50 g/fed. in the presence of 20 kg N/fed. gave increase up to 45.4% and 23.0% of the control, respectively. Yanni *et al.* (1982) stated that inoculation with BGA and increasing the nitrogen fertilizer rates increased plant N-content at booting stage and plant height and effective tillers at maturity. Khadr *et al.* (1985) found that introducing algae without N-

fertilization did not yield significant increase in rice grains and straw and their N-content. Algalization in addition to 50% of the recommended N-fertilizer rate using *Anabaena oryzae* produced about the same yield of rice grain of that received all the recommended N-fertilizer rate. However, the N-taken up by rice grain and straw markedly increased. Application of all the recommended rate of N-fertilizer in addition to algalization did not affect the yield, while its N-content was higher as compared with that received the same N-fertilizer rate only. However, Ghazal (1987) showed the BGA had no statistically significant effect neither on rice yield, nor on organic matter. Yanni *et al.* (1988) found that number of panicles/hill, productive tillers/m^2, grain yield and grain protein and N-contents, showed highly significant increase in case of algalization with the fresh inoculum as compared to the dried one. Furthermore, all the forementioned parameters beside plant height at harvest and 1000-grain rice weight showed highly significant increases with increasing fertilizer-N application rates.

From the previous studies reviewed herein, it could be concluded that algalization of rice under Egyptian conditions increases yield.

In India:

Chandrakar *et al.* (1983) reported that application of 80 kg algae/ha to rice grown at several locations increased

the paddy yield by up to 19% and showed a residual effect on seed yield of *Cicer arietinum*. Krisnarajan and Balasubramaniyan (1983) observed significant increase in yield in the treatments where BGA were inoculated at 10 kg crust/ha. There was no significant difference between the treatments when BGA was applied with 25 kg N/ha. Beri and Meelu (1983) found that algae inoculation increased yield by up to 1300 kg/ha, depending in part on level of applied N and cultural conditions (upland versus lowland). Blue-green algae inoculation and N level significantly affected yield. Patel *et al.* (1984) found that rice yield increased with N level from 25 to 75 kg N/ha. Application of 10 kg BGA/ha gave significantly higher yield over the control in 1979 and 1980. In 1980, heavy rains fell immediately after BGA inoculation and reduced effect on yield. Inoculation of 10 kg dried BGA/ha produced rice yield equivalent to that with 25 kg N/ha. Pillai *et al.*(1984) indicated that with applying 0, 30, 60 or 90 kg N/ha alone or with 5 or 10 kg BGA/ha, grain yield was 3.31, 3.81, 4.39 and 4.72 t/ha with the 4 rates of nitrogen and 3.92 and 4.19 t/ha with the 2 algal treatments, respectively. Straw yield followed similar pattern. Blue-green algae replaced about 30 kg N/ha. Ram and Rawat (1984) applied BGA at a rate of 10 kg/ha to rice in multi location trials during 1979-83. Yield increases were equivalent to those obtained by applying 20-40 kg N/ha. On the other hand, Sarken and Islam (1984) found that algal supplements significantly increased rice yield and nitrogen uptake. The

highest grain yield of 3.81 t/ha (46% over that treatment of 90 kg N/ha and 123% over the control) was obtained for an uptake of 67.4 kg N/ha due to the combined effect of 90 kg N and 10 kg BGA. Sawashe *et al.* (1985) found that inoculation with a culture of BGA 10 days after transplanting increased paddy yield even in the absence of N. Combined application with 25, 50, 75 or 100 kg N/ha indicated that inoculation gave yield increases equivalent to about 25 kg N. In his pot experiments, Goyal (1985) studied the effect of algalization in presence of five sources of combined nitrogen at two levels. While, the rice crop responded significantly to monoammonium phosphate, urea and ammonium sulphate as compared to nitrogen sources, algal supplementation resulted in pronounced increase in the grain yield in presence of nitrogen, particularly at lower levels. Mahapatra *et al.* (1986) indicated that mixed culture of BGA (a 10 kg algal flakes/ha alone or in combination with urea 25 kg N/ha), increased the yield by 5.5 and 9.4% over the control and urea 25 kg N/ha in splits. In the same year, Ram *et al.* (1986) showed that 40 or 60 kg N/ha increased rice grain from 3.2 to 4.1 t/ha, while 10 kg BGA/ha increased yield to 3.9 t/ha. Also, Rao (1986) reported that increasing N rates (0-150 kg N/ha) significantly increased the yield components and yield. inoculation of BGA significantly increased the yield. Singh and Singh (1986) stated that BGA inoculated after transplanting in combination with 30 kg N/ha applied all once, or a 2-split treatment. gave good grain yield but

significantly lower yield than 60 kg N/ha urea alone. This was clarified later by the same authors Singh and Singh (1987) who indicated that significant increases in tiller numbers, plant height, panicle number, panicle weight, straw yield and nitrogen uptake were observed in dual cropping with Azolla and BGA. Grain yield of 4.0 and 4.12 tons were obtained with dry and fresh BGA inoculum, respectively. Grain and nitrogen yield with Azolla and BGA were comparable with those obtained from 30 kg N/ha. Straw yield in BGA dual cropping was significantly lower than after application of 30 kg N/ha as urea. In a pot experiments, Amarit *et al.* (1987) applied 0 or 0.4 g of mixed cultures of N-fixing BGA/kg to rice grown on soil selected from 4 paddy rice-growing areas. Grain yields per pot without fertilizer were 32.07, 34.87, 8.86 and 21.49 g. Corresponding yields with biofertilizer were 53.14, 49.53, 20.02 and 49.60 g/pot. Grain protein without fertilizer was 5.03, 5.14, 6.75 and 5.25% corresponding protein contents with fertilizer were 6.45, 6.53, 7.80 and 7.11%. Nitrogen uptake, straw wt., stem number/tiller, plant height and number of panicles and field grains/panicle were increased by fertilizer use. Singh *et al.* (1988) stated that BGA inoculation had a significant effect on the grain and straw yield only during the dry season in the treatment where 30 kg N was applied. During the wet season and in the other treatments performed during the dry season no significant increase in yields were obtained. The analysis of soil from rice field after harvest

showed that BGA with rice in combination with chemical fertilizer significantly increased the organic carbon and total nitrogen of soil. Rudraraju and Reddy (1988) found that algalization alone did not produce a statistically significant increase in rice yield and other yield parameters. When algalization was supplemented with 100 kg/ha of super phosphate profuse alga growth and a higher yield, equivalent to that obtained with 30 kg N/ha was observed. Algalization together with 30 kg N/ha resulted in better algal growth but had no significant effect on grain yield in comparison with 30 kg N/ha alone. Also, Mahapatra and Sharma (1988) found that application of 10 kg BGA/ha in combination with 25 kg N/ha gave yield similar to 50 N/ha. In their field experiments for 2 years, Pandiyarajan and Rajamannar (1988) reported that inoculation of fertilized 127.5 kg N/ha rice plants with blue-green algae increased grain yield from 2.9 to 3.6 t/ha and increased straw yield from 7.0 to 7.9 t/ha. Inoculation of rice given no nitrogen fertilizer increased grain yield from 2.0 to 2.3 t/ha and straw yield from 4.6 to 5.4 t/ha. Later Patra *et al.* (1989) indicated that blue-green alga alone and in combination with 20, 40 and 60 kg N/ha gave 2-year av. paddy yields of 2.76, 3.17, 3.38 and 3.47 t/ha, respectively, compared with 2.12 t without algae or nitrogen. Blue-green algae in combination with increasing nitrogen rates increased nitrogen uptake in grains and straw. In their 4-year field experiments, Singh and Shrivastava (1990) observed that inoculation of 10 kg

BGA algal crust/ha gave a grain yield and net profit nearly equivalent to that with 25 kg N/ha. Net profit increased when supplemented with 25 kg N/ha. In field trials during 2 years, Hassan *et al.* (1990) tested the effect of blue-green algae on rice yield in Kashmir. Using certain rice variety (K 39), provided with 500 kg lime/ha and 0.5 kg Mo before transplanting and/or soil inoculation with 10 kg BGA mixture (*Nostoc, Anabaena, Aulosira and Toypothrix*) one week after transplanting 30, 45 or 60 kg N was applied. Grain and straw yield were increased as nitrogen rate increased. Yield increases were greater at lower N rates. Yield were highest with lime + Mo + BGA inoculation with 60 kg N but the greatest yield increases were at 30 and 45 kg N.

In Bangladesh:

Bhulya *et al.* (1984) showed that neither N application nor BGA inoculation affected 1000-grain weight but both increased grain yield. A combination of 40 kg N and 10 kg BGA/ha gave the highest grain yield (5.92 t/ha) which was 44% higher than the untreated control (4.02 t/ha). The grain yield of the inoculation treatment given no fertilizer was 200 kg/ha higher than that of the uninoculated treatment with 60 kg N/ha. In pot experiments, Main and Stewart (1985) observed that nitrogen uptake by rice was increased by 91, 167 and 215% by incorporating Azolla, *Anabaena and Nostoc*, which resulted in increased total dry matter yield of 74, 105 and 125%, respectively.